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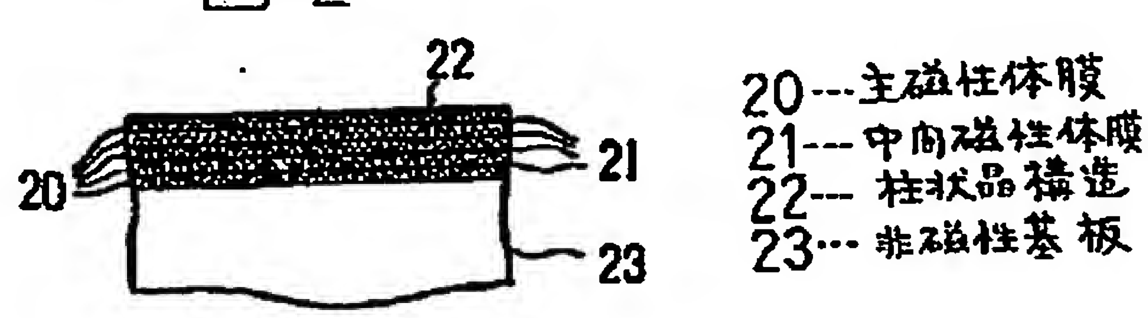
(54)【発明の名称】　磁性体膜およびそれを用いた磁気ヘッド

(57)【要約】
【目的】高保磁力記録媒体に対して優れた記録再生特性を示す磁気ヘッド用の磁性体膜を提供するものであって、特に磁性体膜が高飽和磁束密度の磁性体からなり、低い保磁力で高透磁率を有する積層磁性体膜と、それを用いた高密度記録再生用磁気ヘッドを実現する。
【構成】磁性体膜を構成する主要部分が、厚さ０．５μm以下のＦｅを主成分とする結晶質の高飽和磁束密度を有する磁性合金からなる主磁性体膜と、厚さ１００Å以下の中間磁性体膜とを積層した磁性体膜。または、積層した単位磁性体膜を、非磁性絶縁物よりなる中間層を介して複数積層した磁性体膜とする。これらの磁性体膜を磁気ヘッドのコア部材として用いる。
【効果】低い保磁力で高透磁率が得られ、高周波特性に優れた膜厚の大きい積層磁性体膜が得られる。これを磁気ヘッドに用いることにより、特に高保磁力記録媒体に対して優れた記録再生特性を示し、高密度磁気記録再生用ヘッドが実現できる。

図 2



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【特許請求の範囲】

【請求項１】磁性体膜を構成する主要部分が、厚さ０．５μm以下のＦeを主成分とする結晶質の磁性合金からなる主磁性体膜と、該主磁性体膜とは組成の異なる磁性合金からなる厚さ１００Å以下の中間磁性体膜とを少なくとも積層してなることを特徴とする磁性体膜。

【請求項２】前記主磁性体膜および中間磁性体膜を積層して構成した単位積層磁性体膜と、非磁性絶縁物よりなる中間膜とを積層して構成したことを特徴とする請求項１記載の磁性体膜。

【請求項３】前記主磁性体膜は、単層膜としたときに柱状または針状の結晶構造を有することを特徴とする請求項１または請求項２記載の磁性体膜。

【請求項４】前記主磁性体膜は、単層膜としたときに数Oeの保磁力を有することを特徴とする請求項１ないし請求項３のいずれか１項記載の磁性体膜。

【請求項５】前記主磁性体膜は、単層膜としたときに１００００ガウス以上の飽和磁束密度を有することを特徴とする請求項１ないし請求項５のいずれか１項記載の磁性体膜。

【請求項６】前記主磁性体膜は、Ｆeを主成分とし、Ｓi、Ａｌ、Ｔiのうちから選ばれる少なくとも１種の元素を含む磁性合金からなることを特徴とする請求項１ないし請求項５のいずれか１項記載の磁性体膜。

【請求項７】前記主磁性体膜は、Ｆe以外の元素を１０重量％以下の範囲で含有する磁性合金であることを特徴とする請求項１ないし請求項６のいずれか１項記載の磁性体膜。

【請求項８】前記主磁性体膜は、ＣrまたはＰtを含有する磁性合金であることを特徴とする請求項１ないし請求項７のいずれか１項記載の磁性体膜。

【請求項９】前記中間磁性体膜は、ＣoまたはＮiを主成分とする磁性合金からなることを特徴とする請求項１ないし請求項８のいずれか１項記載の磁性体膜。

【請求項１０】前記主磁性体膜の単層の厚さが０．０５～０．３μmの範囲であることを特徴とする請求項１ないし請求項９のいずれか１項記載の磁性体膜。

【請求項１１】前記中間磁性体膜の単層の厚さが１０～８０Åの範囲であることを特徴とする請求項１ないし請求項１０のいずれか１項記載の磁性体膜。

【請求項１２】前記中間磁性体膜の単層の厚さが１５～７０Åの範囲であることを特徴とする請求項１ないし請求項１０のいずれか１項記載の磁性体膜。

【請求項１３】前記非磁性絶縁物よりなる中間膜は、SiO_2、Al_2O_3、Ａｌ、Moのうちから選ばれる少なくとも１種の非磁性絶縁物からなることを特徴とする請求項１ないし請求項１２のいずれか１項記載の磁性体膜。

【請求項１４】前記磁性体膜は、その膜面に対して所定方向の磁界を印加して形成したものであることを特徴とする請求項１ないし請求項１３のいずれか１項記載の磁性体膜。

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【請求項１５】前記磁性体膜は、非磁性基板上に形成してなることを特徴とする請求項１ないし請求項１４のいずれか１項記載の磁性体膜。

【請求項１６】磁気ギャップを形成する磁気コア部材と、該コア部材に磁気的に結合されるコイル手段を有する磁気ヘッドにおいて、上記コア部材は、厚さ０．５μm以下のＦeを主成分とする結晶質の磁性合金からなる主磁性体膜と、該主磁性体膜とは組成の異なる磁性合金からなる厚さ１００Å以下の中間磁性体膜を積層して構成した磁性体膜、もしくは前記主磁性体膜と中間磁性体膜とを積層して構成される単位積層磁性体膜と、非磁性絶縁物よりなる中間膜とを積層して構成した磁性体膜により構成したことを特徴とする磁気ヘッド。

【請求項１７】前記磁気コア部材は、厚さ０．５μm以下の主磁性体膜と、厚さ１０～８０Åの中間磁性体膜とを積層して構成したことを特徴とする請求項１６記載の磁気ヘッド。

【請求項１８】前記磁気コア部材は、主磁性体膜および中間磁性体膜を積層して構成した単位積層磁性体膜と、非磁性絶縁物よりなる中間膜とを積層して構成した磁性体膜からなることを特徴とする請求項１６または請求項１７記載の磁気ヘッド。

【請求項１９】前記磁気コア部材を構成する主磁性体膜は、単層膜としたときに柱状または針状の結晶構造を有することを特徴とする請求項１６ないし請求項１８のいずれか１項記載の磁気ヘッド。

【請求項２０】前記磁気コア部材を構成する主磁性体膜は、単層膜としたときに数Oeの保磁力を有することを特徴とする請求項１６ないし請求項１９のいずれか１項記載の磁気ヘッド。

【請求項２１】前記磁気コア部材を構成する主磁性体膜は、単層膜としたときに１００００ガウス以上の飽和磁束密度を有することを特徴とする請求項１６ないし請求項２０のいずれか１項記載の磁気ヘッド。

【請求項２２】前記磁気コア部材を構成する主磁性体膜は、Ｆeを主成分とする高飽和磁束密度を有する磁性合金からなることを特徴とする請求項１６ないし請求項２１のいずれか１項記載の磁気ヘッド。

【請求項２３】前記磁気コア部材を構成する高飽和磁束密度を有するＦeを主成分とする磁性合金からなる主磁性体膜は、Ｓi、Ａｌ、Ｔiのうちから選ばれる少なくとも１種の元素を含む磁性合金であることを特徴とする請求項１６ないし請求項２２のいずれか１項記載の磁気ヘッド。

【請求項２４】前記磁気コア部材を構成するＦeを主成分とする磁性合金からなる主磁性体膜は、Ｆe以外の元素を１０重量％以下の範囲で含有する磁性合金であることを特徴とする請求項１６ないし請求項２３のいずれか１項記載の磁気ヘッド。

【請求項２５】前記磁気コア部材を構成する主磁性体膜は、ＣｒまたはＰｔを含有する磁性合金であることを特徴とする請求項１６ないし請求項２４のいずれか１項記載の磁気ヘッド。

【請求項２６】前記磁気コア部材を構成する中間磁性体膜は、CoまたはNiを主成分とする磁性合金からなることを特徴とする請求項１６ないし請求項２５のいずれか１項記載の磁気ヘッド。

【請求項２７】前記磁気コア部材を構成する主磁性体膜の単層の厚さが０．０５～０．３μmの範囲であることを特徴とする請求項１６ないし請求項２６のいずれか１項記載の磁気ヘッド。

【請求項２８】前記磁気コア部材を構成する中間磁性体膜の単層の厚さが１０～８０Åの範囲であることを特徴とする請求項１６ないし請求項２７のいずれか１項記載の磁気ヘッド。

【請求項２９】前記磁気コア部材を構成する中間磁性体膜の単層の厚さが１５～７０Åの範囲であることを特徴とする請求項１６ないし請求項２７のいずれか１項記載の磁気ヘッド。

【請求項３０】前記磁気コア部材を構成する非磁性絶縁物よりなる中間膜は、SiO_2、Al_2O_3、Ａｌ、Moのうちから選ばれる少なくとも１種の非磁性絶縁物からなることを特徴とする請求項１６ないし請求項２９のいずれか１項記載の磁気ヘッド。

【請求項３１】前記磁気コア部材を構成する磁性体膜は、その膜面に対して所定方向の磁界を印加して形成したものであることを特徴とする請求項１６ないし請求項３０のいずれか１項記載の磁気ヘッド。

【請求項３２】前記磁気コア部材を構成する磁性体膜は、非磁性基板上に形成したものであることを特徴とする請求項１６ないし請求項３１のいずれか１項記載の磁気ヘッド。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は磁性体膜に係り、特に磁気ヘッド用のコア材料として、高密度磁気記録に好適な性能を発揮する磁性体膜およびそれを用いた磁気ヘッドに関する。

【０００２】

【従来の技術】磁気記録の高密度化の進歩はめざましく、メタルテープの出現によって従来の酸化物テープの保磁力Hcが６００～７００ Oe（エルステッド）に対して１２００～１６００ Oeのものが容易に得られるようになった。このような高保磁力記録媒体に十分に記録するためには、高飽和磁束密度を有する磁気ヘッド用の磁性材料が要求される。高飽和磁束密度を有する磁性材料はFe、Co、Niを主成分とした合金で、１００００ガウス以上のものを容易に得ることができる。従来、磁気ヘッド等に金属磁性材料を用いる場合は高周波領域における渦電流損を抑えるために磁性体膜を電気的に絶縁して積層した構造がとられている。その製造方法はスパッタリング、蒸着、イオンプレーティングやメッキ等の、いわゆる薄膜形成技術によって行われる。図１は、従来の積層磁性体膜の構造を示す図である。すなわち、

非磁性基板１３上に磁性体層１０と非磁性絶縁層１１を交互に順次形成し、積層体を得るものが公知である（例えば、特開昭４９－１２７１９５号公報）。ここで、各磁性体層１０の厚さは数ミクロン、非磁性体層１１はその１／１０程度の厚さを有している。しかし、結晶質の金属磁性体膜１２（例えば、Feを主成分とし、Ｓｉ、Ａｌ、Ｔｉ等との合金膜、あるいはNi－Fe合金膜）は、図１に示すような柱状構造を示すため、柱状構造の境界で磁化を動き難くし、保磁力を大きくしていることがある。そのため、保磁力の大きい磁性体膜で磁気ヘッドを作製した場合、外部から大きな磁界が与えられたときに磁気ヘッドコアが帯磁してしまうという問題があった。この問題を解決するために、サブミクロン厚さの磁性体層と１００Å程度の厚さの非磁性体層とを交互に積層することによって保磁力を低減させる方法がある（例えば、特開昭５２－１１２７９７号公報）。例えば、スパッタリングによって得られた約１μm厚さのＦｅ－６．５％Ｓｉ合金の単層膜では数エルステッドの保磁力を有するが、上記の方法によれば保磁力を１ Oe程度にまで低減させることができる。しかし、最も低い保磁力を示すものでも０．８ Oe程度が限度であった。そのため、磁気ヘッド材料としては満足できるものではなかった。

【０００３】

【発明が解決しようとする課題】本発明の目的は、上述した従来技術における問題点を解消し、高保磁力記録媒体に対して優れた記録再生特性を示す磁気ヘッド用の磁性体膜を提供することにあり、特に主磁性体膜が高飽和磁束密度を有する強磁性体膜からなり、低い保磁力で、高透磁率を有する積層磁性体膜と、それを用いた磁気ヘッドを提供することにある。

【０００４】

【課題を解決するための手段】本発明は、従来の方法で形成された磁性体層と非磁性体層とを交互に積層した積層磁性体膜では得られない低保磁力の磁性体膜を、１００００ガウス以上の高飽和磁束密度を有する結晶質のＦｅ、ＣｏまたはＮｉを主成分とする金属磁性体を用いて容易に得られるようにしたものである。本発明者らは、上記の積層磁性体膜は、従来の積層磁性体膜において磁性体層間に設ける中間膜としての非磁性体層の代りに、前記磁性体層と異なる磁性体層を中間膜として用いることによって達成できることを見出した。具体的に言えば、本発明の磁性体膜は、厚さ０．５μm以下の主磁性体膜と、厚さ１００Å以下の中間磁性体膜を積層して形成されるものである。

【０００５】図２は、本発明の磁性体膜の構造の一例を示す断面図である。　図において、２０は高飽和磁束密度を有する、例えば鉄を主成分とする磁性合金からなる主磁性体膜、２１は鉄以外のCo、Ｎi等を主成分とする磁性合金からなる中間磁性体膜、２３は非磁性基板である。この中間磁性体膜２１は、厚さ１００Å以下のごく薄い層からなり、主磁性体膜２０は柱状晶構造が磁気的に大きな悪影響を与えない程度の膜厚となるように形成し、中間磁性体層２１によって主磁性体膜２０の柱状晶構造２２が細分化されている。このような構造にすれば、柱状組織に沿って膜面に垂直に向っていた磁化や、柱状組織の境界で動き難くなっていた磁化が、膜面内に向き、膜面内を小さな磁界で動くようになるので、保磁力が小さくなる。また、中間磁性体膜２１が各主磁性体膜２０の磁気的連結を補い、磁化の動きを助けているものと思われる。

【０００６】本発明は、Feを主成分とする高飽和磁束密度（１００００ガウス以上）を有する複数の主磁性体膜と該主磁性体膜間に介在するＦe以外の金属元素を主成分とする中間磁性体膜からなる積層構造を有する磁性体膜である。本発明の主磁性体膜は、例えばFeを主成分とし、Ｓi、Ａl、Ｔiの中から選ばれる少なくとも１種、または２種以上を含み、磁歪が小さく、透磁率の高い、高飽和磁束密度を有する強磁性合金膜からなるものである。なお、主磁性体膜の組成は、耐食性、耐摩耗性、磁歪制御等の目的で、Ｃr、Ｐt等の他の添加物を１０％以下の量で添加してもよい。ただし、１２００ Oe以上の高保磁力の磁気記録媒体に適用する磁気ヘッド材料として用いる場合には、主磁性体膜の飽和磁束密度を１００００ガウス以上に確保することが望ましい。一方、中間磁性体膜は、CoあるいはNi、もしくは、これらの元素を主体とした合金からなっていることが望ましい。また、Ｆeは単体で用いると、その柱状組織が主磁性体膜の柱状組織とつながってしまうため、あまり良い結果は得られないが、ＮiまたはCoを主体にした合金、例えば、$Co_{80}Fe_{20}$合金を用いれば本発明の効果が得られる。本発明は、主磁性体膜が単層膜において、柱状（または針状）構造を示すような結晶質の強磁性体膜において有効である。特に、単層膜において数エルステッドの保磁力を有する磁性体膜に本発明を適用すれば、保磁力を約１桁低減することが可能である。本発明における主磁性体膜の各層の厚みは０．５μm以下、好適には０．０５～０．３μmであることが望ましい。０．０５μm以下では中間磁性体膜の磁性が勝り、０．５μm以上では柱状組織の影響が強く、保磁力が大きくなってしまう。また、中間磁性体膜の各層の厚みは１００Å以下が好ましく、より好ましい範囲は１０～８０Å、最も好適には１５～７０Åとすることが望ましい。１０Å以下では、主磁性体膜の柱状組織を完全に遮断することが困難となり、８０Å以上では中間磁性体膜の磁性が強調され保磁力が大きくなってしまう。上記のような主磁性体膜と、中間磁性体膜とを積層した本発明の積層磁性体膜は、従来の主磁性体膜と非磁性絶縁物よりなる中間膜で構成した積層磁性体膜に比べ、保磁力の低い磁性体膜を得ることができる。さらに、前記の主磁性体膜と中間磁性体膜とからなる適当な厚さの単位積層磁性体膜を、SiO_2、Al_2O_3膜のような電気絶縁性のある非磁性体膜を介して所定枚数積層することによって、高周波特性の優れた本発明の膜厚の大きい積層磁性体膜を得ることができる。本発明の積層磁性体膜は、スパッタリング、蒸着、イオンプレーティングやメッキ等のいわゆる薄膜形成技術によって形成することができる。

【０００７】

【実施例】以下、本発明の実施例を挙げ、図面を用いてさらに詳細に説明する。磁性体膜の形成は、図３に示すようなＲＦスパッタリング装置を用いた。真空容器３０内には３つの独立した対向電極を有し、電極３１、３２、３３はターゲット電極（陰極）で、電極３１にはFeを主成分とした主磁性体膜を形成するための合金ターゲットが配置され、電極３２には中間磁性体膜を形成するためのＦe以外のCo、Ｎi等の磁性金属を主体とする磁性ターゲットが配置され、電極３３には中間非磁性体層を形成するためのSiO_2、Al_2O_3、Ａl、Mo等の絶縁体あるいは非磁性金属からなるターゲットが配置される。一方、電極３４、３５、３６は、それぞれ前記ターゲット電極３１、３２、３３の直下に設けた試料電極（陽極）で、試料３７は目的に応じてそれぞれの試料電極上に移動できるようになっている。また、スパッタリング時には電磁石３８、３８′によって、　試料３７の面内に磁界が印加されるようになっている。なお、放電はアルゴンガス中で行われ、ガス導入管３９から真空容器３０内に入る。４０は、容器３０の排気孔、４１は、電極切り換え器である。

【０００８】<実施例１>まず、主磁性体膜としての高飽和磁束密度を有するFe－６．５％Ｓi（重量％）膜の形成について述べる。比較的好条件でスパッタリングするために選ばれた諸条件は以下のようである。

ターゲット組成…Fe－６．５％Ｓi
高周波電力密度…２．８W／cm^2
アルゴン圧力……2×10^{-2}Torr
基板温度　………３５０℃
電極間距離　……２５mm
膜厚　……………１．５μm

得られた単層膜の磁気特性は、保磁力Hc；２．５ Oe、５MHｚにおける透磁率μ；４００、飽和磁束密度Ｂs；１８５００ガウスであった。なお、スパッタリング中には磁性体膜の面内に一方向の磁界（約１０ Oe）が印加されている。試料の磁気特性は磁性体膜の磁化困難軸方向で測定した結果を示す。また、基板としてはガラス基板を用いた。スパッタリングに際しての諸条件は、

ターゲット組成をFe－6．5％Siとすると Fe側に組成がずれる傾向にあり、堆積された膜の組成は5～6％Siとなる。高周波電力密度は2W／cm²以上にした方が、保磁力Hcが低減する傾向にある。基板温度は膜の歪応力を緩和するために300℃以上にするのが好ましい。電極間距離は短い方が保磁力が低くなる傾向にあり、スパッタリング中の放電の安定性を加速すると、20～30mm程度が好ましい。また、アルゴンガス導入前の真空容器の真空度は酸素や不純物の残存が磁性体膜の磁気特性に影響するので、10^{-7}Torr以上の高真空にすることが好ましい。一方、中間膜の形成は、一般にRFスパッタリングで行われている以下の条件で行った。

【0009】ターゲット材料…Co、Ni、$Co_{80}Fe_{20}$およびSiO_2、Al_2O_3、Al、Mo、Fe
高周波電力密度…0．5W／cm²
アルゴン圧力……5×10^{-3}Torr
基板温度　………250℃
電極間距離　……50mm
膜厚　……………30Å

中間膜にCo、Niからなる磁性体膜との比較のために、Fe膜および従来用いられているSiO_2、Al_2O_3からなる絶縁体膜ならびにAl、Mo等の非磁性金属膜を用いたものについても実験した。積層磁性体膜において、主磁性体膜の一層の膜厚を0．1μmとし、中間膜の膜厚を30Åとし、主磁性体膜を15層積層して全膜厚を約1．5μmとした。図4は上記のようにして得たFe－6．5％Si膜を主磁性体膜とし、種々の中間膜を用いた積層磁性体膜の磁気特性を示す図表である。同図表中の磁気特性は、それぞれスパッタリングしたままの膜の平均値を示す。また、図表中、（イ）はFe－6．5％Si合金の単層膜の特性、（ロ）～（ホ）は従来の非磁性材を中間膜とした積層磁性体膜の特性、（ヘ）はFeを中間膜とした本発明と類似する積層磁性体膜の特性、（ト）～（リ）はFe以外の磁性金属を主体とした磁性金属を中間膜とした本発明の磁性体膜の特性である。同図表の結果によれば、Co、Niおよび$Co_{80}Fe_{20}$を中間膜とした本発明の磁性体膜は、Feおよび従来の非磁性体膜を中間膜とした磁性体膜に比べて保磁力が非常に小さいことが分かる。すなわち、保磁力が0．5 Oe以下となり、実用的な透磁率を得ることができた。

【0010】本発明において、主磁性体膜の一層の膜厚は0．05～0．5μmの範囲で、積層磁性体膜の磁気特性に悪影響を与えない程度に柱状組織を微細化することができる。図5はFe－6．5％Si膜を主磁性体膜とし、Coを中間膜とした時の中間膜の膜厚と保磁力Hcおよび5MHzでの透磁率μの関係を示したものである。この積層磁性体膜は、15層の主磁性体膜と、それらの間に中間膜を設けたものである。この図によると中間膜の膜厚は10～80Åの範囲で保磁力が約0．8 Oe、15～70Åの範囲で保磁力が0．5 Oe以下となり、40Å付近で最小となる。一方、透磁率はこの付近で最大となる。中間膜の膜厚の影響は、材質によって若干異なるものの、ほぼ同等の範囲で好適な磁気特性が得られる。なお、10Å以下の膜厚では、主磁性体膜の組織を遮断することが困難となり、柱状組織が成長してしまうため本発明の効果は低減する。一方、80Å以上にすると、中間膜の磁気的性質が強調され、保磁力が大きくなってしまう。中間膜の膜厚は直接測定することが困難であるため、数ミクロンの膜厚に被着したときのスパッタリング速度から算出して時間で管理した。本実施例では、スパッタリング中に磁性体膜の面内に一方向の磁界が印加されており、磁界印加方向に磁化容易軸が形成される。図6に示すように周波数を変えて磁界印加方向（磁化容易軸方向）で測定した透磁率（曲線51）より、印加磁界と垂直方向（磁化困難軸方向）で測定した透磁率（曲線52）の方が高くなっている。したがって、本発明の積層磁性体膜を磁気ヘッドの作製に用いる場合に、磁化困難軸方向を磁気ヘッドの磁気回路に対して有利な方向に配置することができる。

【0011】<実施例2>本実施例は、本発明の積層磁性体膜により得られる保磁力について、従来の積層構造の磁性体膜と比較して示すものである。例えば、Fe－9．5％Si－6％Al合金をターゲットとし、以下の条件でスパッタリングして得られた積層磁性体膜は、0．2 Oeの保磁力が恒常的に得られる。なお、従来型の積層構造（例えば、中間膜にSiO_2膜を用いた場合）で得られた保磁力は0．5 Oeであった。

ターゲット組成…Fe－10％Si－6．5％Al
高周波電力密度…2．5W／cm²
アルゴン圧力……1×10^{-3}Torr
基板温度　………350℃
電極間距離　……30mm
Fe－Si－Al合金の膜厚…0．2μm
中間膜　…………Co
Coの膜厚　……30Å
合金膜の層数……8
中間膜の層数……7
保磁力Hc　……0．2 Oe
飽和磁束密度……9000ガウス

本発明に用いる主磁性体膜はFeを主成分とする磁性体膜であってもよいが、高飽和磁束密度を有し、ほぼ磁歪が零付近であるFe以外のCoまたはNiを主成分とする合金磁性体であれば十分な効果が生じる。特に、薄膜形成技術によって形成された、膜体が膜面に垂直あるいは傾斜した柱状構造を示す磁性体膜において保磁力が低減され、磁気ヘッド材料として好適な積層磁性体膜を得ることができる。

【0012】<実施例3>図7は、膜構造に関する本発明の実施例を示すものであって、厚膜積層磁性体膜の構

造を示すものである。非磁性基板２３の上に、主磁性体膜２０と中間磁性体膜２１を交互に積層した厚さ数ミクロンの単位積層膜ごとに、非磁性絶縁物よりなる中間膜２４を形成してなる積層磁性体膜である。このように構成した積層磁性体膜は、高周波領域での透磁率の劣化がなく優れた磁気ヘッドコア材となる。このような積層磁性体膜はトラック幅が１０μm以上のビデオヘッド材料として用いられる。

【００１３】＜実施例４＞以下に、本発明の磁気ヘッドの実施例について説明する。本発明の磁気ヘッドは、磁気ギャップを形成するコア部材と、コア部材に磁気的に結合されるコイルを有する磁気ヘッドで、コア部材を２種以上の磁性体膜を積層して形成したものである。このようにコアを形成することで、磁性体膜同士の磁気的なつながりを保ったまま、磁性体膜の結晶構造を制御することができる。この結果、単層では保磁力が大きい磁性体膜であっても、磁気ヘッドコアとした時の保磁力は小さく、透磁率は大きくなり、優れた特性の磁気ヘッドを構成できる。図８には、上述の積層磁性体膜を非磁性基板上に形成してから、所定の形状に加工し、ギャップ形成面が互いに対向するように突き合せて作った磁気ヘッドの一例を示す。図において、６１は、磁性体膜が形成された非磁性基板、６２は積層磁性体膜、６３は、積層磁性体膜６２を保護するためのもう一方の非磁性基板であって、他方の基板または磁性体膜にガラス等で接着されている。６４はギャップ、６５はコイル巻線窓である。この例では、積層磁性体膜６２の厚さがトラック幅となる。図９は、上述した本発明の積層磁性体層を用いた薄膜磁気ヘッドの構造の一例を示すものである。図９（イ）は磁気ヘッドコア断面図、図９（ロ）は上面図である。図において、７１は非磁性基板、７２は下部磁性体膜、７３は上部磁性体膜、７４は導体コイル、７５は作動ギャップである。この例では、磁性体膜は数ミクロン以下の膜厚でよいので、図７に示すような非磁性絶縁物よりなる中間膜２４を省くことができる。図１０は、図９に示す磁気ヘッドの作動ギャップ近傍の磁性体膜の主要部拡大図である。図１０（イ）は下部磁性体膜７２、上部磁性体膜７３を、柱状構造の大きい単層膜で形成した場合の一例を示す。この場合、曲り部７６、７７のよううな、曲りをもつ部分で柱状組織が乱れ、その部分でひび割れが生じたり、また腐食が起る原因となる。また、曲りの部分での応力集中によってクラックを生じる。図１０（ロ）に示す本発明による積層磁性体膜によれば、曲り部７６、７７で結晶組織が細かく、均一にして連続的で応力集中も少ないためクラックを生じることもなく、耐食性の良い磁気回路を形成することができる。

【００１４】

【発明の効果】以上詳細に説明したごとく、本発明の厚さ０．５μm以下のFeを主成分とする結晶質の磁性合金

からなる主磁性体膜と、厚さ１００Å以下の中間磁性体膜とを積層した磁性体膜、あるいは主磁性体膜と中間磁性体膜を所定数積層した単位積層磁性体膜と、非磁性絶縁物よりなる中間膜を積層して構成した磁性体膜は、低い保磁力で、高透磁率が得られる。また、単位積層磁性体膜を電気絶縁性の非磁性絶縁物よりなる中間膜を介して複数積層することにより高周波特性に優れた膜厚の大きい積層磁性体膜が得られる。したがって、本発明の磁性体膜を磁気ヘッドのコア材として用いることにより、特に高保磁力記録媒体に対して優れた記録再生特性を示す高密度磁気記録再生用ヘッドを実現することができる。

【図面の簡単な説明】

【図１】従来の積層磁性体膜の断面構成を示す模式図。

【図２】本発明の積層磁性体膜の断面構成の一例を示す模式図。

【図３】本発明の実施例において磁性体膜の形成に用いたスパッタリング装置の構成を示す模式図。

【図４】本発明の実施例１で例示したFe－６．５％Si合金膜を主磁性体膜とし、種々の中間膜を用いた積層磁性体膜の磁気特性を示す図表。

【図５】本発明の実施例１で例示したFe－６．５％Si合金膜を主磁性体膜とし、Coを中間膜とした本発明の積層磁性体膜の磁気特性を示すグラフ。

【図６】本発明の実施例１で例示したFe－６．５％Si合金膜を主磁性体膜とし、Coを中間膜とした本発明の積層磁性体膜の磁気特性を示すグラフ。

【図７】本発明の実施例３で例示した本発明の他の積層磁性体膜の断面構成を示す模式図。

【図８】本発明の実施例４で例示した積層磁性体膜を用いて作製した磁気ヘッドの構成を示す模式図。

【図９】本発明の実施例４で例示した薄膜磁気ヘッドの構造を示す模式図。

【図１０】本発明の実施例４で例示した磁気ヘッドの作動ギャップ近傍の磁性体膜の構成を示す拡大図。

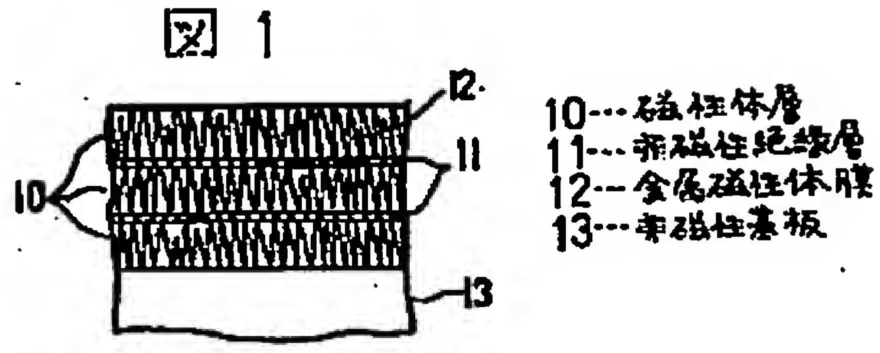
【符号の説明】

１０…磁性体層
１１…非磁性絶縁層
１２…金属磁性体膜
１３…非磁性基板
２０…主磁性体膜
２１…中間磁性体膜
２２…柱状晶構造
２３…非磁性基板
２４…非磁性絶縁物よりなる中間膜
３０…真空容器
３１、３２、３３…電極（ターゲット…陰極）
３４、３５、３６…電極（試料電極…陽極）
３７…試料
３８、３８′…電磁石

３９…ガス導入管
４０…排気口
４１…電極切り換え器
５１…磁化容易軸方向の透磁率
５２…磁化困難軸方向の透磁率
６１…非磁性基板
６２…積層磁性体膜
６３…非磁性基板
６４…ギャップ
６５…コイル巻線窓
７１…非磁性基板
７２…下部磁性体膜
７３…上部磁性体膜
７４…導体コイル
７５…作動ギャップ
７６、７７…曲り部

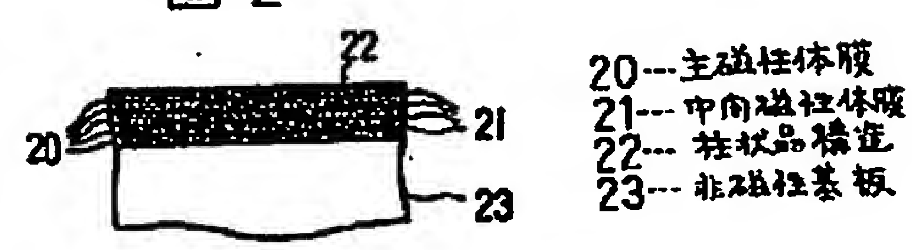
【図１】

図 1



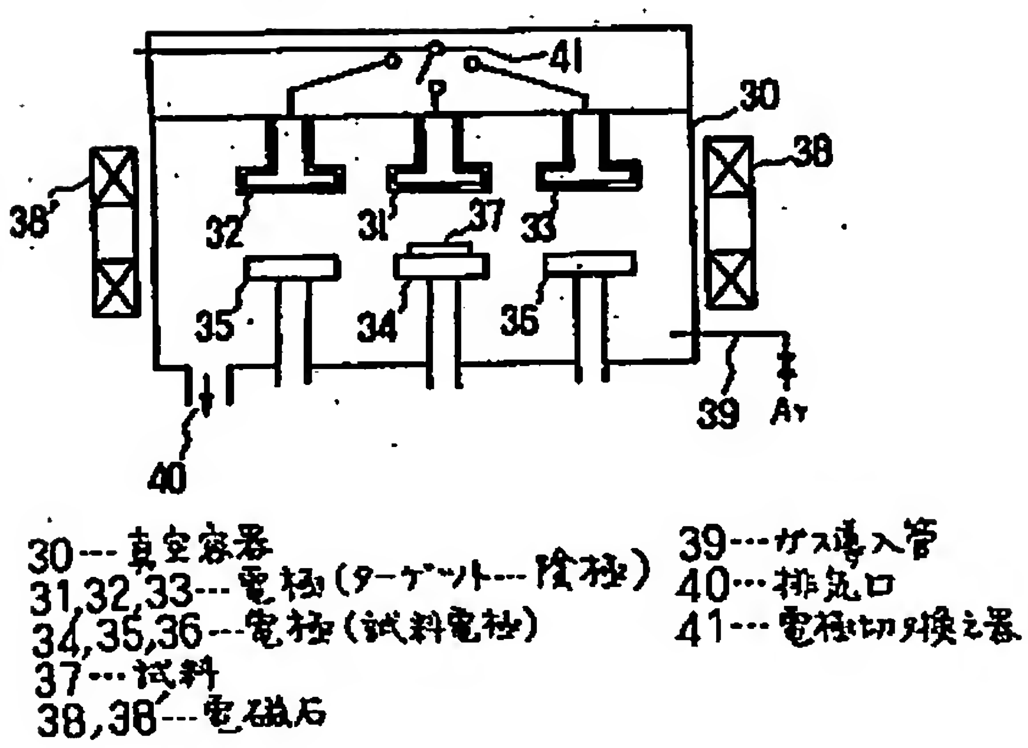
【図２】

図 2



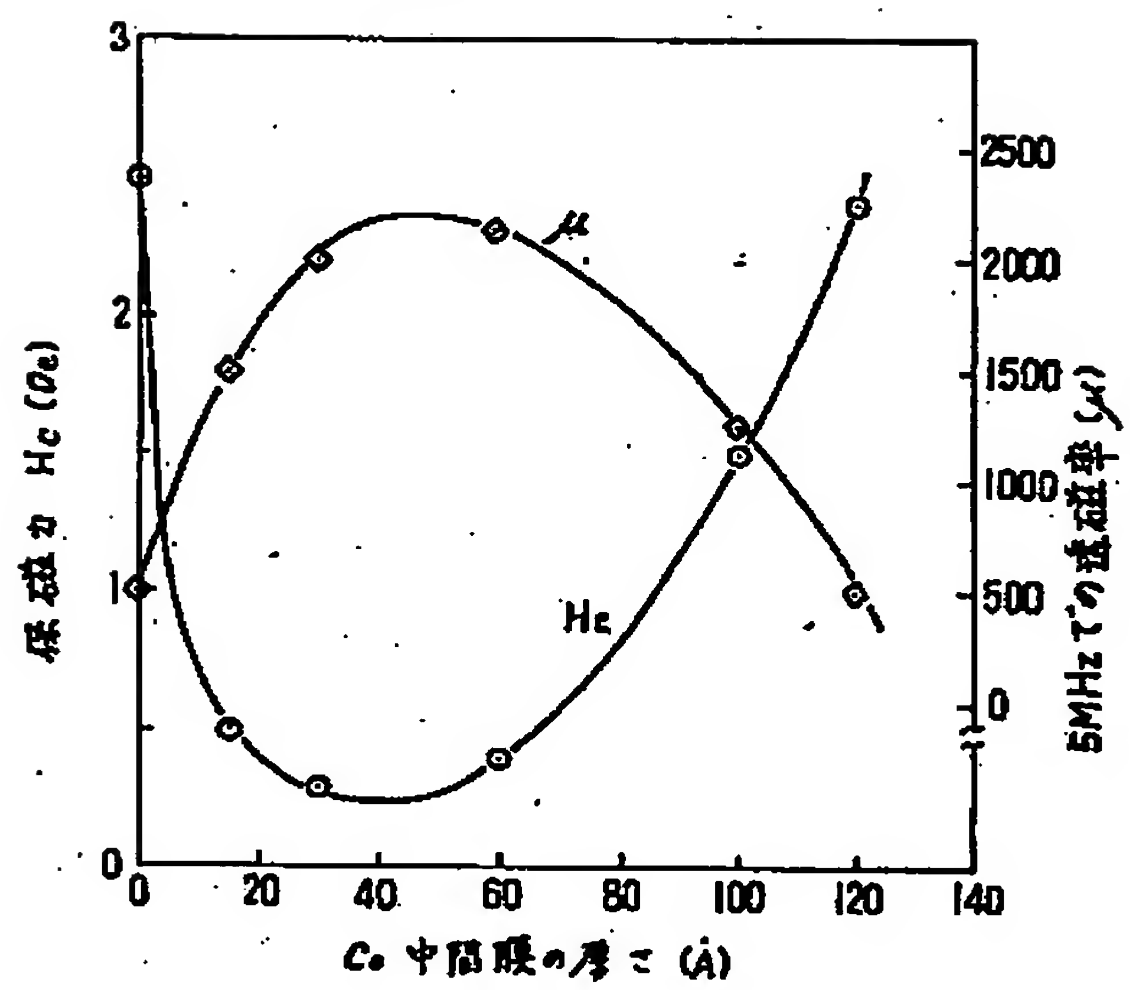
【図３】

図 3



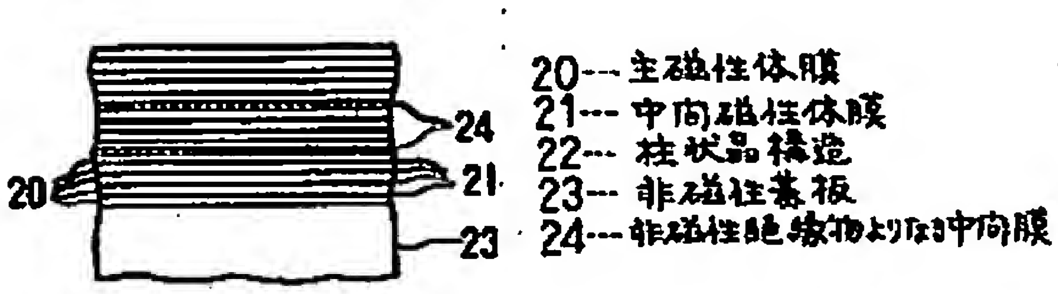
【図５】

図 5



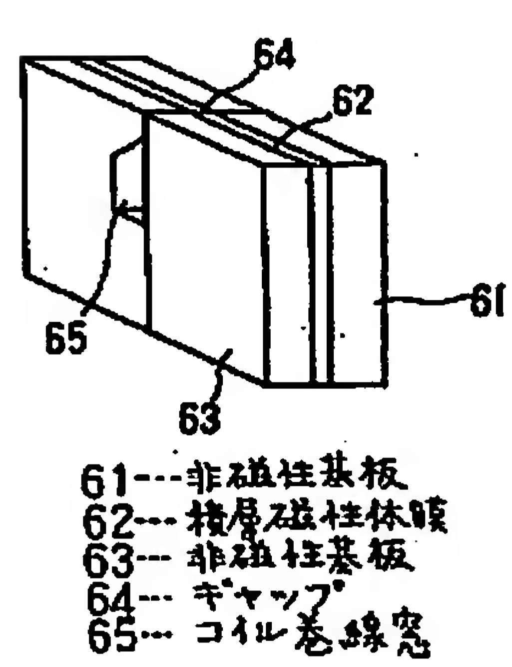
【図７】

図 7



【図８】

図 8



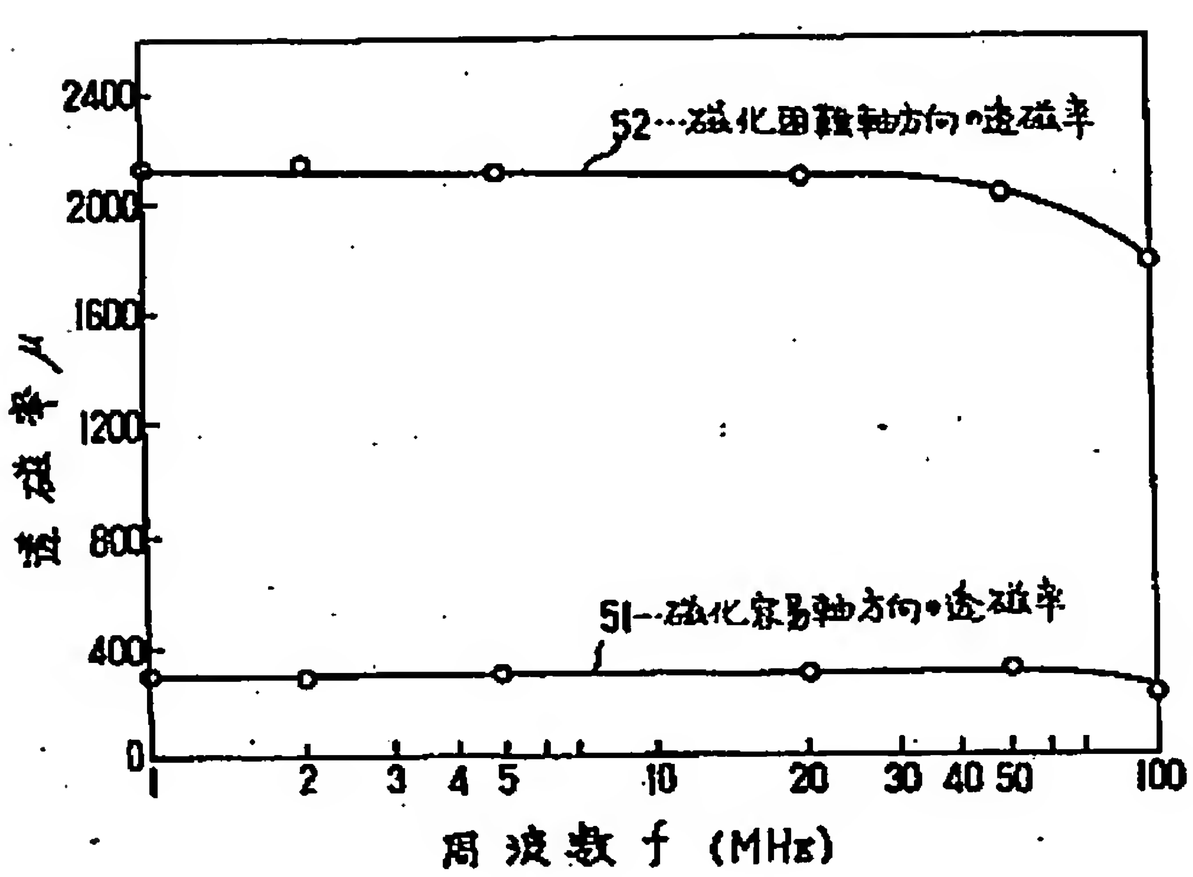
【図4】

図 4

磁気特性			保磁力 Hc (Oe)	透磁率 μ (5MHz)	飽和磁束密度 Bs (G)
(イ) 単層膜			2.5	400	18000 〜 19000
積層膜の中間膜	絶縁物	(ロ) SiO_2	1.0	2000	
		(ハ) Al_2O_3	1.3	18000	
	非磁性金属	(ニ) Al	1.2	1200	
		(ホ) Mo	0.9	900	
	磁性金属	(ヘ) Fe	1.2	900	
		(ト) Co	0.3	2200	
		(チ) Ni	0.5	900	
		(リ) $Co_{80}Fe_{20}$	0.4	2000	

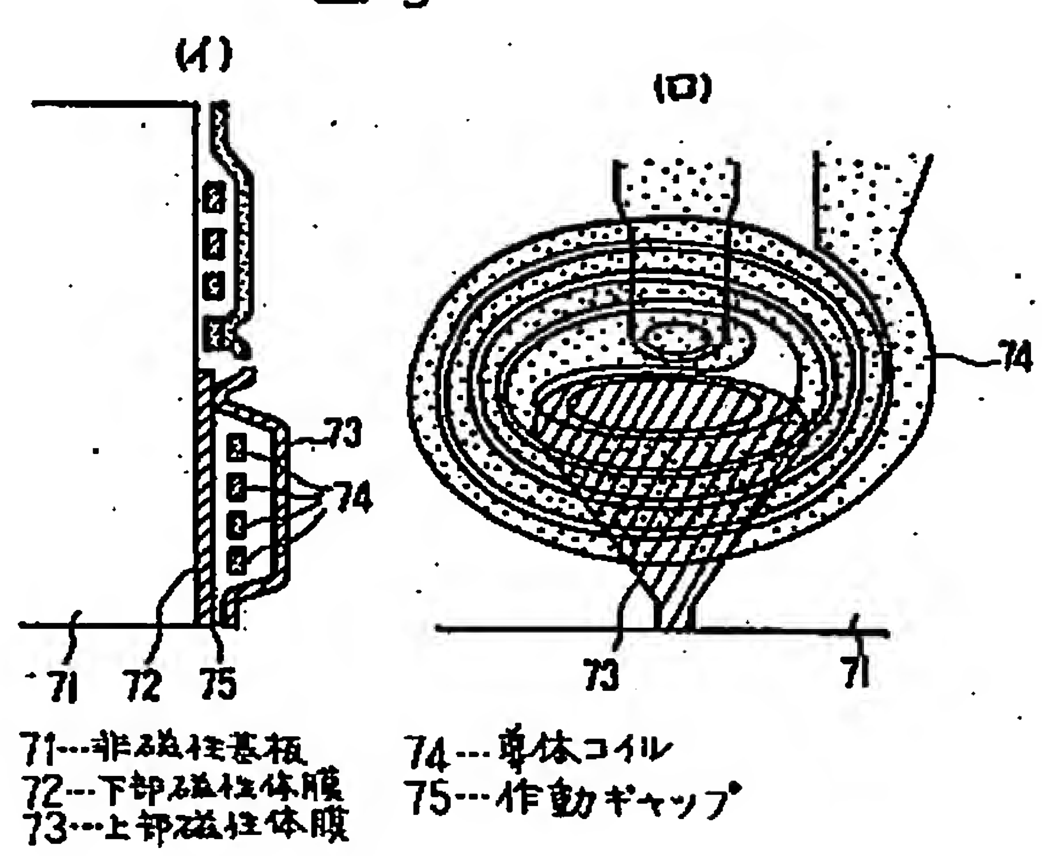
【図6】

図 6



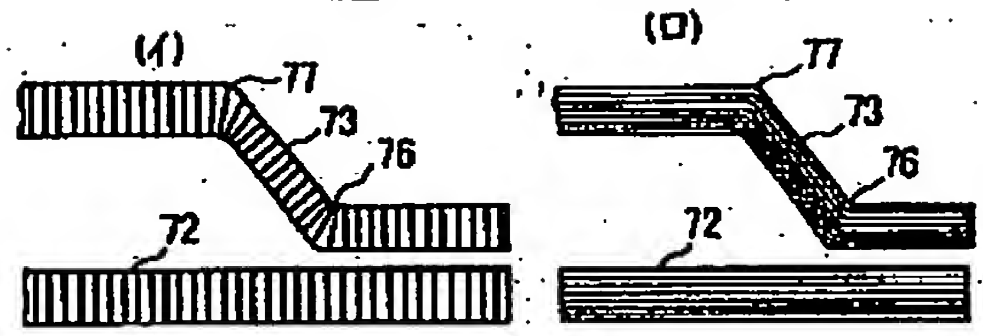
【図9】

図 9



【図１０】

図10



72…下部磁性体膜
73…上部磁性体膜
76, 77…曲り部

フロントページの続き

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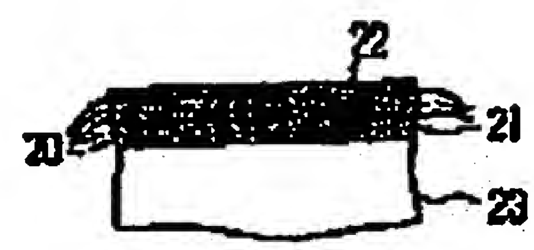
(54) MAGNETIC MATERIAL FILM AND MAGNETIC HEAD USING THE SAME

(57)Abstract:
PURPOSE: To provide a magnetic material film for magnetic head use to show superior recording production characteristics to a high-coercive force recording medium by a method wherein main magnetic material films, which respectively have a prescribed thickness, and intermediate magnetic material films, which respectively have a prescribed thickness, are laminated.



CONSTITUTION: A magnetic material film has a high saturation flux density. Main magnetic material films 20 consisting of a magnetic alloy containing iron, for example, as its main component and intermediate magnetic material films 21 consisting of a magnetic alloy containing Co, Ni or the like other than the iron as its main component are respectively laminated on a non-magnetic substrate 23. These films 21 consist of a very thin layer of a thickness of 100Å or thinner and the films 20 are formed in such a way that their film thicknesses become a film thickness of 0.5μm or thinner in an extent that a columnar crystallographic structure does not exert magnetically a large adverse effect. Thereby, a high permeability is obtained by a low coersive force and a laminated magnetic material film, which is superior in high-frequency characteristics and is thick in film thickness, is obtained. By using this laminated magnetic material film for a magnetic head, a head for high-density magnetic recording reproduction use to show specially superior recording reproduction characteristics to a high-coercive force recording medium can be realized.

LEGAL STATUS

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the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The main magnetic-substance film with which the amount of [which constitutes the magnetic-substance film] principal part consists of a magnetic alloy of the crystalline substance which uses Fe with a thickness of 0.5 micrometers or less as a principal component, and this main magnetic-substance film are magnetic-substance film characterized by coming at least to carry out the laminating of the middle magnetic-substance film with a thickness of 100A or less it is thin from the magnetic alloy with which presentations differ.
[Claim 2] Magnetic-substance film according to claim 1 characterized by having carried out the laminating of the unit laminating magnetic-substance film which carried out the laminating of said main magnetic-substance film and the middle magnetic-substance film, and constituted them, and the interlayer which consists of a nonmagnetic insulating material, and constituting it.
[Claim 3] Said main magnetic-substance film is magnetic-substance film according to claim 1 or 2 characterized by having the crystal structure pillar-shaped when it considers as monolayer, or needlelike.
[Claim 4] Said main magnetic-substance film is magnetic-substance film of claim 1 characterized by having the coercive force of Number Oe when it considers as monolayer thru/or claim 3 given in any 1 term.
[Claim 5] Said main magnetic-substance film is magnetic-substance film of claim 1 characterized by having saturation magnetic flux density 10000 gauss or more when it considers as monolayer thru/or claim 5 given in any 1 term.
[Claim 6] Said main magnetic-substance film is magnetic-substance film of claim 1 which uses Fe as a principal component and is characterized by consisting of a magnetic alloy containing at least one sort of elements chosen from from among Si, aluminum, and Ti thru/or claim 5 given in any 1 term.
[Claim 7] Said main magnetic-substance film is magnetic-substance film of claim 1 characterized by being the magnetic alloy which contains elements other than Fe in 10 or less % of the weight of the range thru/or claim 6 given in any 1 term.
[Claim 8] Said main magnetic-substance film is magnetic-substance film of claim 1 characterized by being a magnetic alloy containing Cr or Pt thru/or claim 7 given in any 1 term.
[Claim 9] Said middle magnetic-substance film is magnetic-substance film of claim 1 characterized by consisting of a magnetic alloy which uses Co or nickel as a principal component thru/or claim 8 given in any 1 term.
[Claim 10] Magnetic-substance film of claim 1 characterized by being the range whose thickness of the monolayer of said main magnetic-substance film is 0.05-0.3 micrometers thru/or claim 9 given in any 1 term.
[Claim 11] Magnetic-substance film of claim 1 characterized by being the range whose thickness of the monolayer of said middle magnetic-substance film is 10-80A thru/or claim 10 given in any 1 term.
[Claim 12] Magnetic-substance film of claim 1 characterized by being the range whose thickness of the monolayer of said middle magnetic-substance film is 15-70A thru/or claim 10 given in any 1 term.

[Claim 13] The interlayer which consists of said nonmagnetic insulating material is magnetic-substance film of SiO2, aluminum 2O3, claim 1 characterized by consisting of at least one sort of nonmagnetic insulating materials chosen from from among aluminum and Mo, or claim 12 given in any 1 term.
[Claim 14] Said magnetic-substance film is magnetic-substance film of claim 1 characterized by impressing and forming the field of the predetermined direction to the film surface thru/or claim 13 given in any 1 term.
[Claim 15] Said magnetic-substance film is magnetic-substance film of claim 1 characterized by coming to form on a nonmagnetic substrate thru/or claim 14 given in any 1 term.
[Claim 16] In the magnetic head which has the coil means magnetically combined with the magnetic-core member which forms a magnetic gap, and this core member the above-mentioned core member The main magnetic-substance film which consists of a magnetic alloy of the crystalline substance which uses Fe with a thickness of 0.5 micrometers or less as a principal component, The magnetic-substance film which carried out the laminating of the middle magnetic-substance film with a thickness of 100A or less it is thin from the magnetic alloy with which a presentation differs from this main magnetic-substance film, and constituted it, or the unit laminating magnetic-substance film constituted by carrying out the laminating of said main magnetic-substance film and the middle magnetic-substance film, The magnetic head characterized by constituting with the magnetic-substance film which carried out the laminating of the interlayer which consists of a nonmagnetic insulating material, and constituted it.
[Claim 17] Said magnetic-core member is the magnetic head according to claim 16 characterized by having carried out the laminating of the main magnetic-substance film with a thickness of 0.5 micrometers or less and the middle magnetic-substance film with a thickness of 10-80A, and constituting them.
[Claim 18] Said magnetic-core member is the magnetic head according to claim 16 or 17 characterized by consisting of magnetic-substance film which carried out the laminating of the unit laminating magnetic-substance film which carried out the laminating of the main magnetic-substance film and the middle magnetic-substance film, and constituted them, and the interlayer which consists of a nonmagnetic insulating material, and constituted it.
[Claim 19] The main magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by having the crystal structure pillar-shaped when it considers as monolayer, or needlelike thru/or claim 18 given in any 1 term.
[Claim 20] The main magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by having the coercive force of Number Oe when it considers as monolayer thru/or claim 19 given in any 1 term.
[Claim 21] The main magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by having saturation magnetic flux density 10000 gauss or more when it considers as monolayer thru/or claim 20 given in any 1 term.
[Claim 22] The main magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by consisting of a magnetic alloy which has the high saturation magnetic flux density which uses Fe as a principal component thru/or claim 21 given in any 1 term.
[Claim 23] The main magnetic-substance film which consists of a magnetic alloy which uses as a principal component Fe which has the high saturation magnetic flux density which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by being a magnetic alloy containing at least one sort of elements chosen from from among Si, aluminum, and Ti thru/or claim 22 given in any 1 term.
[Claim 24] The main magnetic-substance film which consists of a magnetic alloy which uses as a principal component Fe which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by being the magnetic alloy which contains elements other than Fe in 10 or less % of the weight of the range thru/or claim 23 given in any 1 term.
[Claim 25] The main magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by being a magnetic alloy containing Cr or Pt thru/or claim 24 given in any 1 term.

[Claim 26] The middle magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by consisting of a magnetic alloy which uses Co or nickel as a principal component thru/or claim 25 given in any 1 term.
[Claim 27] The magnetic head of claim 16 characterized by being the range whose thickness of the monolayer of the main magnetic-substance film which constitutes said magnetic-core member is 0.05-0.3 micrometers thru/or claim 26 given in any 1 term.
[Claim 28] The magnetic head of claim 16 characterized by being the range whose thickness of the monolayer of the middle magnetic-substance film which constitutes said magnetic-core member is 10-80A thru/or claim 27 given in any 1 term.
[Claim 29] The magnetic head of claim 16 characterized by being the range whose thickness of the monolayer of the middle magnetic-substance film which constitutes said magnetic-core member is 15-70A thru/or claim 27 given in any 1 term.
[Claim 30] The interlayer which consists of a nonmagnetic insulating material which constitutes said magnetic-core member is the magnetic head of SiO2, aluminum 2O3, claim 16 characterized by consisting of at least one sort of nonmagnetic insulating materials chosen from from among aluminum and Mo, or claim 29 given in any 1 term.
[Claim 31] The magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by impressing and forming the field of the predetermined direction to the film surface thru/or claim 30 given in any 1 term.
[Claim 32] The magnetic-substance film which constitutes said magnetic-core member is the magnetic head of claim 16 characterized by forming on a nonmagnetic substrate thru/or claim 31 given in any 1 term.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the magnetic head using the magnetic-substance film and it which start the magnetic-substance film, especially demonstrate the suitable engine performance for high density magnetic recording as core materials for the magnetic heads.
[0002]
[Description of the Prior Art] The advance of the densification of magnetic recording is remarkable and the coercive force Hc of the conventional oxide tape came to be easily acquired for the thing of 1200 - 1600 Oe to 600 - 700 Oe (oersted) with the advent of a metal tape. In order to fully record on such a high coercive force record medium, the magnetic material for the magnetic heads which has high saturation magnetic flux density is required. The magnetic material which has high saturation magnetic flux density is the alloy which used Fe, Co, and nickel as the principal component, and can obtain a thing 10000 gauss or more easily. When using a metal magnetic material for the magnetic head etc. conventionally, in order to stop the eddy current loss in a RF field, the structure which insulated electrically and carried out the laminating of the magnetic-substance film is taken. The manufacture approach is performed by the so-called thin film coating technology, such as sputtering, vacuum evaporationo, ion plating, and plating. Drawing 1 is drawing showing the structure of the conventional laminating magnetic-substance film. namely, -- What carries out sequential formation of a magnetic layer 10 and the nonmagnetic insulating layer 11 by turns on the nonmagnetic substrate 13, and obtains a layered product is well-known (for example, JP,49-127195,A). Here, in the thickness of each magnetic layer 10, several microns and the non-magnetic-material layer 11 have about [the] 1/10 thickness. However, since the metal magnetic-substance film 12 (for example, using Fe as a principal component alloy film or nickel-Fe alloy film with Si, aluminum, Ti, etc.) of a crystalline substance shows a columnar structure as shown in drawing 1 , magnetization may be made hard to move by the boundary of a columnar structure, and it may enlarge coercive force. Therefore, when the magnetic head was produced by the large magnetic-substance film of coercive force, and a big field was given from the outside, there was a problem that a magnetic-head core will carry out magnetization. In order to solve this problem, there is a method of reducing coercive force by carrying out the laminating of the magnetic layer of submicron thickness, and the non-magnetic-material layer with a thickness of about 100A by turns (for example, JP,52-112797,A). For example, according to the above-mentioned approach, even 1 Oe extent can be made to reduce coercive force, although it has the coercive force of a number oersted in the monolayer of the Fe-6.5%Si alloy of about 1-micrometer thickness obtained by sputtering. However, it was [0.8 Oe extent] a limit which shows the lowest coercive force. Therefore, it was not what can be satisfied as a magnetic-head ingredient.
[0003]
[Problem(s) to be Solved by the Invention] The purpose of this invention cancels the trouble in the conventional technique mentioned above, is to offer the magnetic-substance film for the magnetic heads in which the record reproducing characteristics which were excellent to the high coercive force record medium are shown, especially the main magnetic-substance film consists of ferromagnetic film which has high saturation magnetic flux density, and is low coercive force, and

is to offer the laminating magnetic-substance film which has high permeability, and the magnetic head using it.
[0004]
[Means for Solving the Problem] This invention is easily obtained using the metal magnetic substance which uses as a principal component Fe, Co, or nickel of the crystalline substance which has high saturation magnetic flux density 10000 gauss or more for the magnetic-substance film of low coercive force which is not obtained by the laminating magnetic-substance film which carried out the laminating of the magnetic layer formed by the conventional approach, and the non-magnetic-material layer by turns. this invention persons found out that the above-mentioned laminating magnetic-substance film could be attained by using said magnetic layer and a different magnetic layer as an interlayer instead of the non-magnetic-material layer as an interlayer prepared between magnetic layers in the conventional laminating magnetic-substance film. Speaking concretely, the magnetic-substance film of this invention carrying out the laminating of the main magnetic-substance film with a thickness of 0.5 micrometers or less and the middle magnetic-substance film with a thickness of 100A or less, and forming it.
[0005] Drawing 2 is the sectional view showing an example of the structure of the magnetic-substance film of this invention. In drawing, the main magnetic-substance film which 20 has high saturation magnetic flux density, for example, consists of a magnetic alloy which uses iron as a principal component, the middle magnetic-substance film which consists of a magnetic alloy with which 21 uses Co(es) other than iron, nickel, etc. as a principal component, and 23 are nonmagnetic substrates. It forms so that it may become the thickness with a thickness of 100A or less of extent on which it becomes from a film very much and, as for the main magnetic-substance film 20, columnar crystal structure does not have a big bad influence magnetically, and as for this middle magnetic-substance film 21, the columnar crystal structure 22 of the main magnetic-substance film 20 is subdivided by the middle magnetic layer 21. If it is made such structure, since the magnetization which was going at right angles to a film surface along columnar structure, and the magnetization it had been hard coming to move by the boundary of columnar structure will come to move the inside of a film surface by the small field toward the inside of a film surface, coercive force becomes small. Moreover, the middle magnetic-substance film 21 compensates magnetic connection of each main magnetic-substance film 20, and is considered to have helped the movement toward magnetization.
[0006] This invention is magnetic-substance film which has the laminated structure which consists of middle magnetic-substance film which uses as a principal component metallic elements other than Fe which intervenes between two or more main magnetic-substance film which has the high saturation magnetic flux density (10000 gauss or more) which uses Fe as a principal component, and this main magnetic-substance film. The main magnetic-substance film of this invention uses Fe as a principal component, and including at least one sort chosen from Si, aluminum, and Ti, or two sorts or more, magnetostriction is small and it consists of ferromagnetic alloy film which has high saturation magnetic flux density with high permeability. In addition, the presentations of the main magnetic-substance film are the purposes, such as corrosion resistance, abrasion resistance, and magnetostriction control, and may add other additives, such as Cr and Pt, in 10% or less of amount. However, when using as a magnetic-head ingredient applied to the magnetic-recording medium of high coercive force more than 1200 Oe, it is desirable to secure the saturation magnetic flux density of the main magnetic-substance film to 10000 gauss or more. On the other hand, as for the middle magnetic-substance film, it is desirable to consist of Co, nickel, or an alloy that made these elements the subject. Moreover, if Fe is used alone, since the columnar structure is connected with the columnar structure of the main magnetic-substance film, a not much good result will not be obtained, but if the alloy which made nickel or Co the subject, for example, Co80Fe20 alloy, is used, the effectiveness of this invention will be acquired. This invention is effective in the ferromagnetic film of a crystalline substance as the main magnetic-substance film shows pillar-shaped (or needlelike) structure to in monolayer. If this invention is applied to the magnetic-substance film which has the coercive force of a number oersted in monolayer especially, it is possible to reduce coercive force a figure single [about]. As for the thickness of each class of the main magnetic-substance film in this invention, it is suitably desirable that it is

0.05-0.3 micrometers 0.5 micrometers or less. By 0.05 micrometers or less, the magnetism of the middle magnetic-substance film excels, by 0.5 micrometers or more, the effect of columnar structure will be strong and coercive force will become large. Moreover, the thickness of each class of the middle magnetic-substance film has desirable 100A or less, and, as for the more desirable range, considering as 15-70A is most suitably desirable 10-80A. By 10A or less, it becomes difficult to intercept the columnar structure of the main magnetic-substance film completely, by 80A or more, the magnetism of the middle magnetic-substance film will be emphasized and coercive force will become large. The laminating magnetic-substance film of this invention which carried out the laminating of the above main magnetic-substance film and the middle magnetic-substance film can obtain the low magnetic-substance film of coercive force compared with the laminating magnetic-substance film constituted from an interlayer which consists of the conventional main magnetic-substance film and a conventional nonmagnetic insulating material. Furthermore, the large laminating magnetic-substance film of the thickness of this invention which was excellent in the RF property can be obtained by carrying out the predetermined number-of-sheets laminating of the suitable unit laminating magnetic-substance film of thickness which consists of the aforementioned main magnetic-substance film and the aforementioned middle magnetic-substance film through the non-magnetic-material film with electric insulation like SiO2 and 2Oaluminum3 film. The laminating magnetic-substance film of this invention can be formed by the so-called thin film coating technology, such as sputtering, vacuum evaporationo, ion plating, and plating.
[0007]
[Example] Hereafter, the example of this invention is given and it explains to a detail further using a drawing. Formation of the magnetic-substance film used RF sputtering system as shown in drawing 3 . In a vacuum housing 30, it has three independent counterelectrodes, and electrodes 31, 32, and 33 are target electrodes (cathode). The alloy target for forming in an electrode 31 the main magnetic-substance film which used Fe as the principal component is arranged. The magnetic target which makes a subject magnetic metals, such as Co(es) other than Fe for forming the middle magnetic-substance film in an electrode 32 and nickel, is arranged. The target which becomes an electrode 33 from an insulator or non-magnetic metal, such as SiO2 and aluminum 2O3 for forming a middle non-magnetic-material layer, and aluminum, Mo, is arranged. On the other hand, electrodes 34, 35, and 36 are sample electrodes (anode plate) prepared directly under said target electrodes 31, 32, and 33, respectively, and a sample 37 can move them now onto each sample electrode according to the purpose. Moreover, at the time of sputtering, it is by the electromagnet 38 and 38'. A field is impressed in the field of a sample 37. In addition, discharge is performed in argon gas and it enters in a vacuum housing 30 from the gas installation tubing 39. 40 is the exhaust hole of a container 30 and 41 is an electrode switch machine.
[0008] <Example 1> Formation of the Fe-6.5%Si (% of the weight) film which has the high saturation magnetic flux density as main magnetic-substance film is described first. The terms and conditions chosen in order to carry out sputtering on good conditions comparatively are as follows.

Target presentation [... 350 degree-C inter-electrode distance .. 25mm thickness ..... The magnetic properties of the monolayer obtained 1.5 micrometers were coercive force Hc;2.5 Oe, the permeability mu; 400 in 5MHz, and saturation-magnetic-flux-density Bs;18500 gauss.] -- Fe-6.5% Si RF power flux density -- 2.8 W/cm2 argon pressure .... 2x10~2Torr substrate temperature In addition, during sputtering, the field (about 10 Oe) of an one direction is impressed in the field of the magnetic-substance film. The magnetic properties of a sample show the result measured in the direction of a hard axis of the magnetic-substance film. Moreover, the glass substrate was used as a substrate. The terms and conditions for sputtering are in the inclination for a presentation to shift to the Fe side, when a target presentation is set to Fe-6.5%Si, and the presentation of the deposited film serves as Si 5 to 6%. RF power flux density has the direction made into two or more 2 W/cm in the inclination which coercive force Hc reduces. In order to ease membranous distorted stress, as for substrate temperature, it is desirable to make it 300 degrees C or more. Inter-electrode distance has about 20-30 desirablemm, when the shorter one has coercive force in the inclination which becomes low and accelerates the stability of discharge

under sputtering. Moreover, since survival of oxygen or an impurity influences the magnetic properties of the magnetic-substance film, as for the degree of vacuum of the vacuum housing before argon gas installation, it is desirable to make it the high vacuum of 10~7 or more Torrs. On the other hand, formation of an interlayer was performed on condition that the following currently generally performed by RF sputtering.
[0009] target ingredient -- Co, nickel, Co80Fe20 and SiO2 and aluminum 2O3, aluminum and Mo, and a Fe RF power-flux-density --0.5W[/cm] 2 argon pressure .... 5x10~3Torr substrate temperature ... 250-degree-C inter-electrode distance .. 50mm thickness .... It experimented also about the thing using non-magnetic metal film which consists of SiO2 and aluminum 2O3 which are used Fe film and conventionally for the comparison with the magnetic-substance film which turns into 30A interlayer from Co and nickel, such as insulator film, and aluminum, Mo. In the laminating magnetic-substance film, much more thickness of the main magnetic-substance film was set to 0.1 micrometers, thickness of an interlayer was made into 30A, the 15-layer laminating of the main magnetic-substance film was carried out, and all thickness was set to about 1.5 micrometers. Drawing 4 is the graph in which using as the main magnetic-substance film the Fe-6.5%Si film obtained as mentioned above, and showing the magnetic properties of the laminating magnetic-substance film using various interlayers. The magnetic properties in this graph show the average of the film [having carried out sputtering, respectively]. Moreover, - (Li) is the property of the magnetic-substance film of this invention which made the interlayer the magnetic metal which made the subject magnetic metals other than the property of the laminating magnetic-substance film that the property of the monolayer of a Fe-6.5%Si alloy, (**) - (**) made the conventional nonmagnetic material the interlayer, as for (**), the property of this invention, to which (**) made Fe the interlayer, and the similar laminating magnetic-substance film, (**), and Fe among a graph. According to the result of this graph, the magnetic-substance film of this invention which made the interlayer Co, nickel, and Co80Fe20 is understood that coercive force is very small compared with the magnetic-substance film which made the interlayer Fe and the conventional non-magnetic-material film. That is, coercive force was able to become below 0.5 Oe and practical permeability was able to be obtained.
[0010] In this invention, the range of much more thickness of the main magnetic-substance film is 0.05-0.5 micrometers, and it can make columnar structure detailed to extent which does not have a bad influence on the magnetic properties of the laminating magnetic-substance film. Relation with the thickness of the interlayer when drawing 5 using the Fe-6.5%Si film as the main magnetic-substance film, and making Co into an interlayer, a coercive force [Hc], and a permeability [mu] of 5MHz is shown. This laminating magnetic-substance film prepares an interlayer between the main magnetic-substance film of 15 layers, and them. According to this drawing, coercive force becomes below 0.5 Oe in the range whose coercive force is about 0.8 Oe and 15-70A in the range of 10-80A, and the thickness of an interlayer serves as min near 40A. On the other hand, permeability serves as max near this. Although the effect of the thickness of an interlayer changes a little with quality of the materials, suitable magnetic properties are acquired in the almost equivalent range. In addition, in thickness 10A or less, it becomes difficult to intercept the main magnetic-substance film tissue, and in order that columnar structure may grow, the effectiveness of this invention is reduced. On the other hand, if it is made 80A or more, the magnetic property of an interlayer will be emphasized and coercive force will become large. Since the thickness of an interlayer was difficult to measure directly, it was computed from the sputtering rate when covering the thickness which is several microns, and was managed by time amount. In this example, the field of an one direction is impressed in the field of the magnetic-substance film during sputtering, and an easy axis is formed in the field impression direction. From the permeability (curve 51) which changed the frequency and was measured in the field impression direction (the direction of an easy axis) as shown in drawing 6 , the permeability (curve 52) measured in the impression field and the perpendicular direction (the direction of a hard axis) is high. Therefore, when using the laminating magnetic-substance film of this invention for production of the magnetic head, the direction of a hard axis can be arranged in the advantageous direction to the magnetic circuit of the magnetic head.
[0011] <Example 2> this example is shown as compared with the magnetic-substance film of the

conventional laminated structure about the coercive force acquired with the laminating magnetic-substance film of this invention. For example, as for the laminating magnetic-substance film obtained by using a Fe-9.5%Si-6%aluminum alloy as a target, and carrying out sputtering on condition that the following, the coercive force of 0.2 Oe is acquired constantly. In addition, the coercive force acquired by the laminated structure of a conventional type (for example, when SiO2 film is used for an interlayer) was 0.5 Oe.
target presentation --Fe-10%Si -- a -6.5%aluminum RF power-flux-density --2.5 W/cm2 argon pressure .... 1x10~3Torr substrate temperature ... 350-degree-C inter-electrode distance .. thickness --0.2-micrometer interlayer of 30 mmFe-Si-aluminum alloy .... Thickness of CoCo .. [.. 7 coercive force Hc / .. 0.2 Oe saturation magnetic flux density .. Although the main magnetic-substance film used for 9000 gauss this invention may be magnetic-substance film which uses Fe as a principal component, it has high saturation magnetic flux density.] Number of layers of 30A alloy film .. Number of layers of eight interlayers If it is the alloy magnetic substance which uses as a principal component Co(es) or nickel other than Fe whose magnetostriction is near zero mostly, sufficient effectiveness will arise. Coercive force is reduced in the magnetic-substance film which was especially formed of thin film coating technology and with which a membrane shows a perpendicular or the inclined columnar structure to a film surface, and the laminating magnetic-substance film suitable as a magnetic-head ingredient can be obtained.
[0012] <Example 3> drawing 7 shows the example of this invention about membrane structure, and shows the structure of the thick-film laminating magnetic-substance film. It is the laminating magnetic-substance film which comes to form the interlayer 24 which consists of a nonmagnetic insulating material on the nonmagnetic substrate 23 for every unit cascade screen with a thickness of several microns which carried out the laminating of the main magnetic-substance film 20 and the middle magnetic-substance film 21 by turns. Thus, the constituted laminating magnetic-substance film serves as magnetic-head core material which does not have degradation of the permeability in a RF field and was excellent. As for such laminating magnetic-substance film, the width of recording track is used as a video head ingredient 10 micrometers or more.
[0013] The example of the magnetic head of this invention is explained below to <the example 4>. The magnetic head of this invention is the magnetic head which has the coil magnetically combined with the core member which forms a magnetic gap, and a core member, carries out the laminating of two or more sorts of magnetic-substance film, and forms a core member. Thus, the crystal structure of the magnetic-substance film can be controlled by forming a core, with magnetic relation of magnetic-substance film maintained. Consequently, even if coercive force is the large magnetic-substance film, the coercive force when considering as a magnetic-head core is small, permeability becomes large, and the magnetic head of the outstanding property can consist of monolayers. After forming the above-mentioned laminating magnetic-substance film on a nonmagnetic substrate, a predetermined configuration is processed into drawing 8 and an example of the magnetic head compared and made so that a gap forming face might counter mutually is shown in it. In drawing, it is a nonmagnetic substrate and in order that the nonmagnetic substrate with which, as for 61, the magnetic-substance film was formed, and 62 may protect the laminating magnetic-substance film and 63 may protect the laminating magnetic-substance film 62, while I will accept it are pasted up on the substrate or magnetic-substance film of another side with glass etc. 64 is a gap and 65 is a coil coil aperture. In this example, the thickness of the laminating magnetic-substance film 62 serves as the width of recording track. Drawing 9 shows an example of the structure of the thin film magnetic head using the laminating magnetic layer of this invention mentioned above. Drawing 9 (b) is a magnetic-head core sectional view, and drawing 9 (b) is a plan. drawing -- setting -- 71 -- a nonmagnetic substrate and 72 -- the lower magnetic-substance film and 73 -- the up magnetic-substance film and 74 -- a conductor -- a coil and 75 are actuation gaps. In this example, since thickness several microns or less is sufficient as the magnetic-substance film, the interlayer 24 which consists of a nonmagnetic insulating material as shown in drawing 7 can be excluded. Drawing 10 is the principal part enlarged drawing of the magnetic-substance film near the actuation gap of the magnetic head shown in drawing 9 . Drawing 10 (b) shows an example at the time of forming the lower magnetic-substance film 72 and the up magnetic-substance film 73 by the large monolayer of a columnar structure. In this case,

columnar structure is arisen in a **** part with a knee so that it may be elbows 76 and 77, a crack arises in turbulence and its part, and it becomes the cause by which corrosion takes place. Moreover, a crack is produced by the stress concentration in the part of a knee. According to the laminating magnetic-substance film by this invention shown in drawing 10 (b), the crystalline structure is fine at elbows 76 and 77, it is continuous, and it can be made homogeneity and a corrosion resistance good magnetic circuit can be formed, without producing a crack, since there is also little stress concentration.

[0014]

[Effect of the Invention] The main magnetic-substance film which consists of a magnetic alloy of the crystalline substance which uses Fe with a thickness [of this invention] of 0.5 micrometers or less as a principal component as explained to the detail above, High permeability is obtained by coercive force with low unit laminating magnetic-substance film which carried out the predetermined number laminating of the magnetic-substance film which carried out the laminating of the middle magnetic-substance film with a thickness of 100A or less or the main magnetic-substance film, and the middle magnetic-substance film and magnetic-substance film which carried out the laminating of the interlayer which consists of a nonmagnetic insulating material, and constituted it. Moreover, the large laminating magnetic-substance film of the thickness excellent in the RF property is obtained by carrying out two or more laminatings of the unit laminating magnetic-substance film through the interlayer which consists of a nonmagnetic insulating material of electric insulation. therefore, the thing for which the magnetic-substance film of this invention is used as core material of the magnetic head -- especially, the head for high density magnetic-recording playback which shows the record reproducing characteristics which were excellent to the high coercive force record medium is realizable.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The mimetic diagram showing the cross-section configuration of the conventional laminating magnetic-substance film.
[Drawing 2] The mimetic diagram showing an example of the cross-section configuration of the laminating magnetic-substance film of this invention.
[Drawing 3] The mimetic diagram showing the configuration of the sputtering system used for formation of the magnetic-substance film in the example of this invention.
[Drawing 4] The graph in which using as the main magnetic-substance film the Fe-6.5%Si alloy film illustrated in the example 1 of this invention, and showing the magnetic properties of the laminating magnetic-substance film using various interlayers.
[Drawing 5] The graph which shows the magnetic properties of the laminating magnetic-substance film of this invention which used as the main magnetic-substance film the Fe-6.5%Si alloy film illustrated in the example 1 of this invention, and made Co the interlayer.
[Drawing 6] The graph which shows the magnetic properties of the laminating magnetic-substance film of this invention which used as the main magnetic-substance film the Fe-6.5%Si alloy film illustrated in the example 1 of this invention, and made Co the interlayer.
[Drawing 7] The mimetic diagram showing the cross-section configuration of other laminating magnetic-substance film of this invention illustrated in the example 3 of this invention.
[Drawing 8] The mimetic diagram showing the configuration of the magnetic head produced using the laminating magnetic-substance film illustrated in the example 4 of this invention.
[Drawing 9] The mimetic diagram showing the structure of the thin film magnetic head illustrated in the example 4 of this invention.
[Drawing 10] The enlarged drawing showing the configuration of the magnetic-substance film near the actuation gap of the magnetic head illustrated in the example 4 of this invention.
[Description of Notations]
10 -- Magnetic layer
11 -- Nonmagnetic insulating layer
12 -- Metal magnetic-substance film
13 -- Nonmagnetic substrate
20 -- Main magnetic-substance film
21 -- Middle magnetic-substance film
22 -- Columnar crystal structure
23 -- Nonmagnetic substrate
24 -- Interlayer which consists of a nonmagnetic insulating material
30 -- Vacuum housing
31, 32, 33 -- Electrode (target -- cathode)
34, 35, 36 -- Electrode (sample electrode -- anode plate)
37 -- Sample
38 38' -- Electromagnet
39 -- Gas installation tubing
40 -- Exhaust port

41 -- Electrode switch machine
51 -- Permeability of the direction of an easy axis
52 -- Permeability of the direction of a hard axis
61 -- Nonmagnetic substrate
62 -- Laminating magnetic-substance film
63 -- Nonmagnetic substrate
64 -- Gap
65 -- Coil coil aperture
71 -- Nonmagnetic substrate
72 -- Lower magnetic-substance film
73 -- Up magnetic-substance film
74 -- a conductor -- a coil
75 -- Actuation gap
76 77 -- Elbow

[Translation done.]

* NOTICES *

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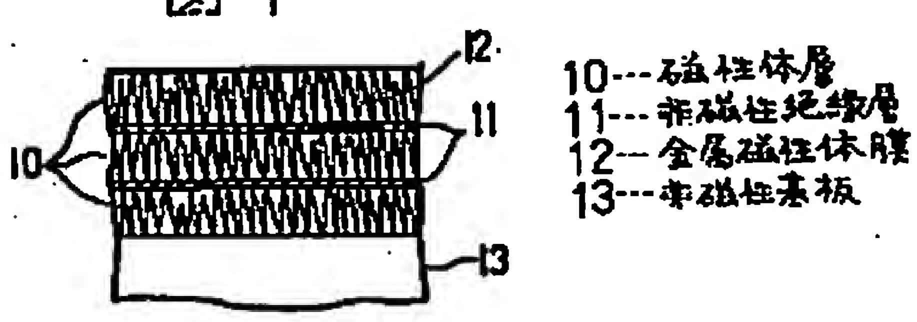
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

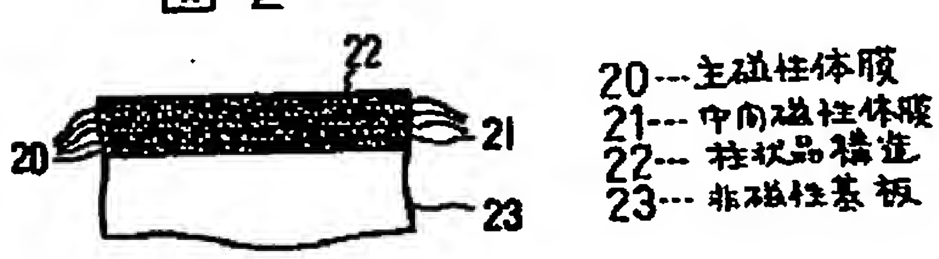
[Drawing 1]

図 1



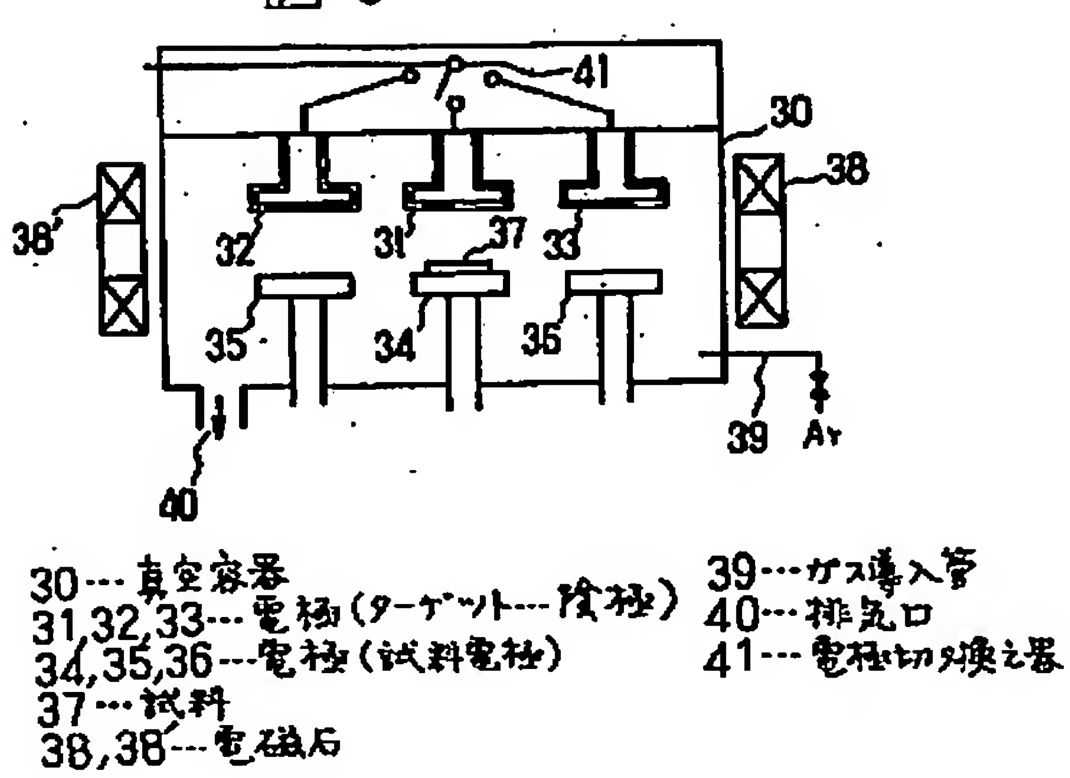
[Drawing 2]

図 2



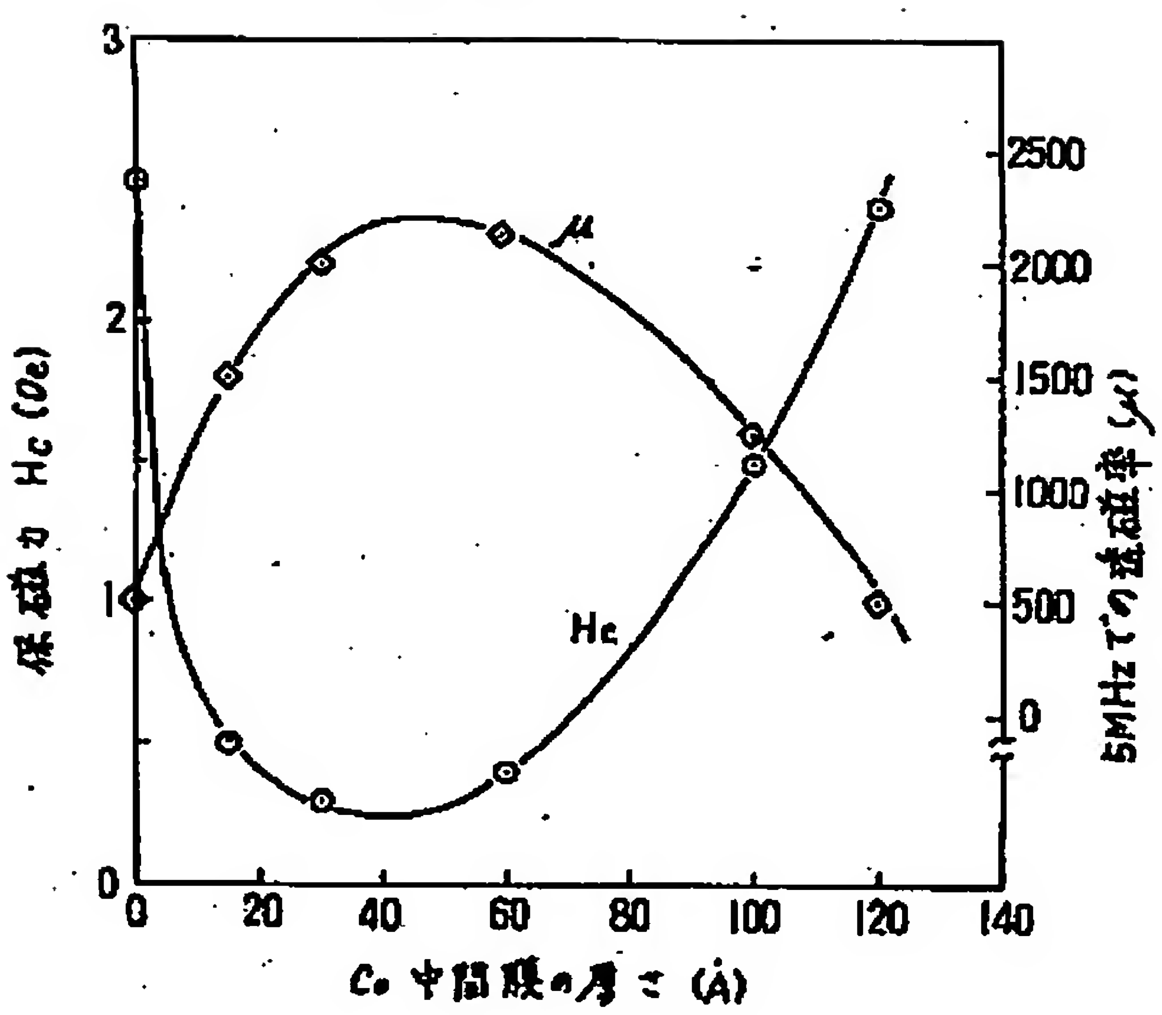
[Drawing 3]

図 3



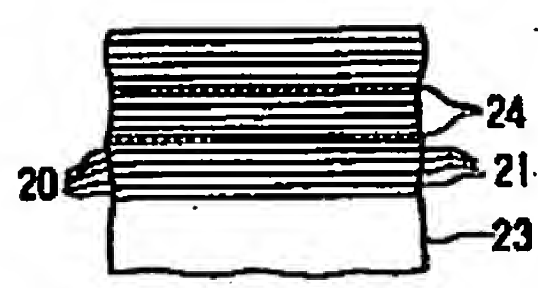
[Drawing 5]

図 5



[Drawing 7]

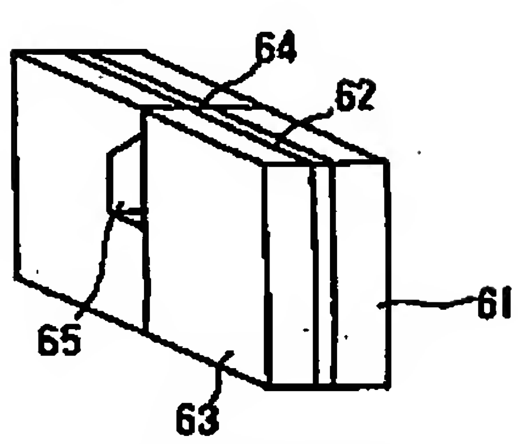
図 7



20--- 主磁性体膜
21--- 中間磁性体膜
22--- 柱状晶構造
23--- 非磁性基板
24--- 非磁性絶縁物よりなる中間膜

[Drawing 8]

図 8



61--- 非磁性基板
62--- 積層磁性体膜
63--- 非磁性基板
64--- ギャップ
65--- コイル巻線窓

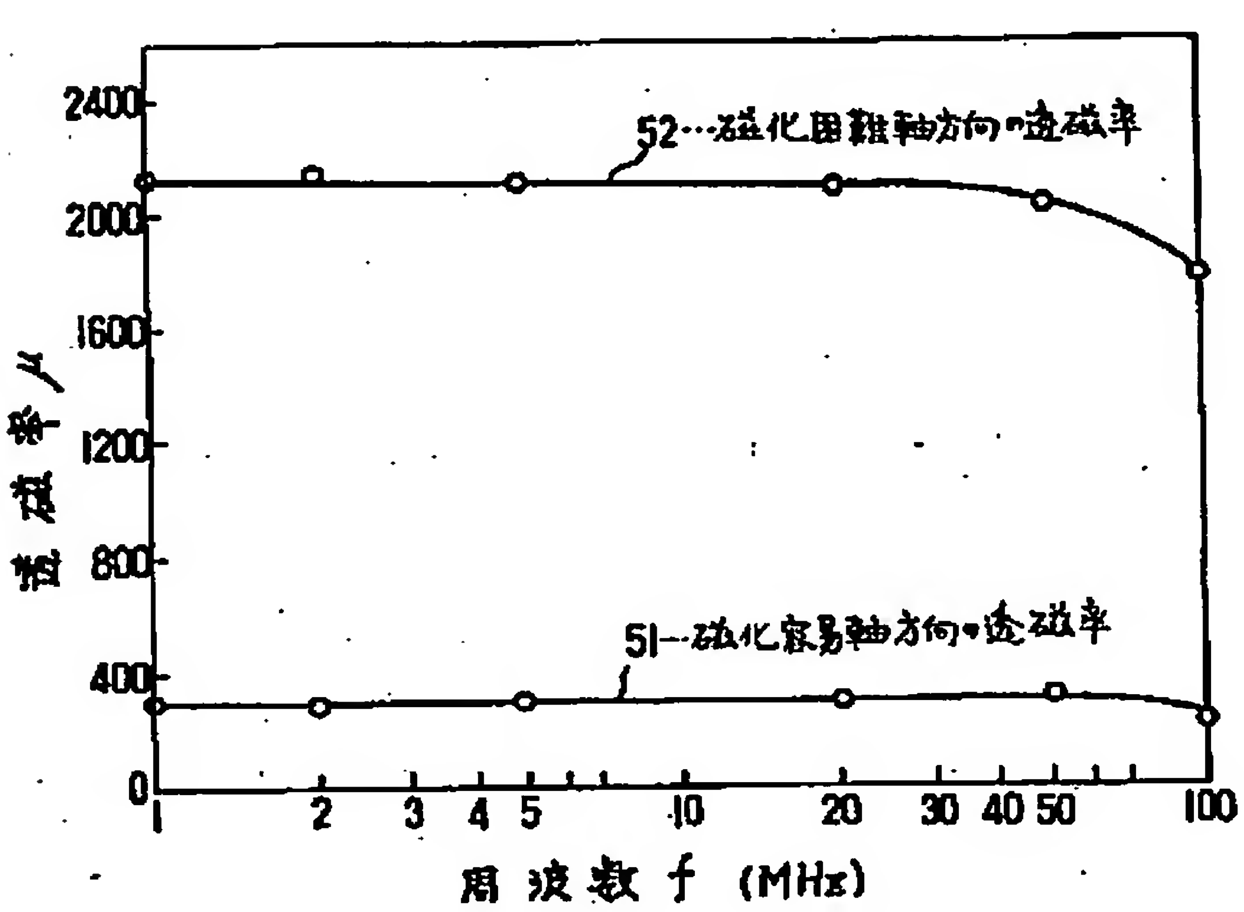
[Drawing 4]

図 4

磁気特性			保磁力 Hc (Oe)	透磁率 μ (5MHz)	飽和磁束密度 Bs (G)
(イ) 単層膜			2.5	400	18000 ～ 19000
積層膜の中間膜	絶縁物	(ロ) SiO_2	1.0	2000	
		(ハ) Al_2O_3	1.3	18000	
	非磁性金属	(ニ) Al	1.2	1200	
		(ホ) Mo	0.9	900	
	磁性金属	(ヘ) Fe	1.2	900	
		(ト) Co	0.3	2200	
		(チ) Ni	0.5	900	
		(リ) $Co_{80}Fe_{20}$	0.4	2000	

[Drawing 6]

図 6



[Drawing 9]